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FINAL REPORT

DYNAMICAL-CHEMICAL COUPLING IN THE
MESOSPHERE AND LOWER THERMOSPHERE

PROFESSOR JEFFREY M. FORBES

AFOSR-81-0090

BOSTON UNIVERSITY
DEPARTMENT OF ELECTRICAL, COMPUTER AND
SYSTEMS ENGINEERING
BOSTON, MA 02215

February 1, 1981 - January 31, 1984

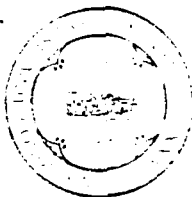
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Boston University

College of Engineering
110 Cummington Street
Boston, Massachusetts 02215
617/353-2800

Electrical, Computer and Systems Engineering



Reply to: Prof. Jeffrey M. Forbes (617-353-4782)
Subject: Grant AFOSR-81-0090 Final Report

Lt. Col. Ted Cress
AFOSR/NC
Bolling AFB
Washington, D.C. 20332

Dear Ted:

As you know, funding of my AFOSR Grant 81-0090 to Boston College was discontinued at the end of its third year due to my transfer to Boston University in January, 1984. We had planned on a small increment (\$21,070) of funding to Boston College to complete that research; you subsequently informed me that these funds would reach me via a re-award to B.U. beginning on or about 1, May 1984 and extending to 30 September 1984.

As per your verbal instructions at the inconerent scatter meeting in Washington, D.C., 22-24 February 1984, this letter constitutes a brief interim final technical report covering the research performed between 1 February 1981 and 31 January 1984 at Boston College. A more comprehensive final technical report, covering both the AFOSR Grant 81-0090 to B.C. (1 February 1981 - 31 January 1984) and the re-award to B.U. (1 May 1984 - 30 September 1984) will be submitted by 1 December 1984.

The primary research goal of Grant AFOSR 81-0090 was to improve our understanding and modelling capabilities of dynamical/chemical coupling processes in the mesosphere and thermosphere. Accomplishments may be categorized into 3 main areas:

1. Diurnal Tide, Theoretical Development and Modelling

The diurnal tide represents an important contribution to the meteorology of the mesosphere and thermosphere. Investigations under AFOSR support have ranged between (a) a full numerical calculation of the viscous tidal equations from the earth's surface to 400 Km taking into account all relevant excitation and dissipation mechanisms, (b) simulations using an f-plane approximation of the interactive feedback between the main propagating tide and the turbulence it generates via a cascade mechanism, and (c) modelling of the longitude variability of the diurnal propagating tide at low latitudes by virtue of the nonmigrating modes which are generated via insolation absorption by longitudinally - varying H₂O in the

troposphere. The latter calculations also include an investigation of scale-dependent radiative cooling by CO₂. Publications reporting the above work are, respectively:

Forbes, J.M., Atmospheric Tides, I. Model Description and Results for the Solar Diurnal Component, J. Geophys. Res. **87**, 5222-5240, 1982.

Lindzen, R.S., and J.M. Forbes, Turbulence Originating from Convectively Stable Internal Waves, J. Geophys. Res., in press.

Forbes, J.M. and G.V. Groves, Diurnal Propagating Tides in the Low-Latitude Middle Atmosphere, J. Atmos. Terr. Phys., Submitted.

2. Development of finite element simulation code (FESC) for modelling dynamical - chemical coupling processes;

A FESC developed and utilized by Prof. M. Mendillo and the Astronomy Department Group at Boston University for modelling F-region chemical releases with characteristic times of less than an hour was modified for the simulation of longer-period phenomena (~ 24 hours) with emphasis on dynamical effects. Modifications for the study of mesosphere/lower thermosphere effects included introduction of (a) photodissociation of O₂, CO₂, H₂O; (b) completely new sets of species, chemical reactions, and diffusion coefficients; (c) eddy diffusion; (d) height-dependent integration time steps; (e) removal or modification of much plasma-related logic not needed for neutral minor constituent simulations; and (f) introduction of a tidal dynamics subroutine. Modifications for the study of F-region dynamical behavior included making provisions for (a) photoionization; (b) winds; (c) electric fields; (d) airglow calculations; and (e) protonospheric replenishment at night. All of these efforts required much debugging and testing against 'known results' at many levels of development. The FESC is now working extremely well.

3. Investigation of specific dynamical-chemical coupling phenomena.

Four main efforts are involved here: (a) Investigation of tidal oscillations in temperature on the thermal break-up of water cluster ions in the D-region, and subsequent effects on effective recombination rate and hence on latitude structure of composition and total plasma density as a function of local time; (b) A review of the fundamental principles and assumptions which lie at the foundation of our current knowledge and perception of mesopause region processes and contemporary models; (c) An FESC simulation of the effects of tides on the latitude and height of structure of the oxygen/hydrogen/carbon photochemistry of the 70 -150 km height region; and (d) An FESC simulation of the so-called 'Mid-night collapse' and 'presunrise rise' of the F-

layer over Arecibo, Puerto Rico. These results are or will be reported as follows:

Forbes, J.M., Temperature and Solar Zenith Angle Control of D-Region Positive Ion Chemistry, Planet. Space Sci., 30, 1065-1072, 1982.

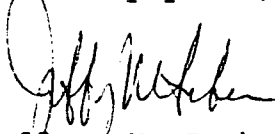
Forbes, J.M., Physics of the Mesopause Region, in Solar Terrestrial Physics: Principles and Theoretical Foundations (ed. by R. L. Carovillano and J.M. Forbes), D. Reidel Co., 1983.

Forbes, J.M., Tidal Variations in the Oxygen-Hydrogen-Carbon Photochemistry of the Upper Mesosphere and Lower Thermosphere (70-150 km), in preparation for submission to Planet and Space Sci.

Crary, D.J., and J.M. Forbes, The Dynamic Ionosphere over Arecibo: A Theoretical Investigation, in preparation for submission to J. Geophys. Res.

I hope that the above constitutes an adequate interim final technical report. If more details are required, please let me know.

Sincerely yours,



Jeffrey M. Forbes
Principal Investigator